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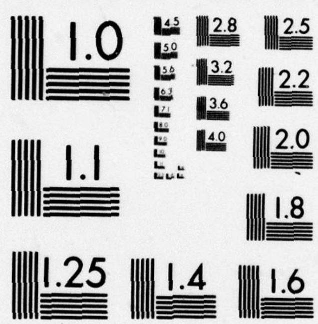

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LIFE CYCLE COST MANAGEMENT GUIDANCE FOR PROGRAM MANAGERS

JULY 1978

DIRECTORATE OF COST ANALYSIS
COMPTROLLER
AERONAUTICAL SYSTEMS DIVISION
WPAFB, OHIO 45433

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LIFE CYCLE COST MANAGEMENT

GUIDANCE FOR PROGRAM MANAGERS.

(FOURTH EDITION)

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FOREWORD

This guide was prepared to help program managers organize and efficiently use their personnel and contractors to design new equipment with reduced life cycle costs. To do this managers must understand how design decisions can affect life cycle cost and know what actions to initiate to ensure that their systems or equipment are designed to minimize life cycle costs. Sections I and II describe the nature and scope of life cycle cost management activities and discuss the effects of design decisions on life cycle cost. Section III addresses how and what actions should be taken to manage engineering and other program activities to ensure that proper consideration is given to life cycle costs during design. Section IV provides a catalog of design and program issues which can significantly affect life cycle costs. This catalog is provided to alert program managers to specific design related questions or issues they should address, if pertinent to their programs, to effectively carry out their responsibilities to reduce life cycle costs. Section V summarizes the responsibilities of program managers in this area and discusses potential sources of assistance in applying life cycle cost management concepts.

This report has been reviewed and approved.

C W Adams

CHARLES W. ADAMS
Deputy Comptroller

I. INTRODUCTION

Background

There has been considerable concern within the Department of Defense for some time about the high cost of defense systems and the rapidly increasing cost of supporting systems after they are placed into operation. The cost of operating and supporting defense systems over their useful life is generally greater than, and often several times greater than, the initial acquisition price. The Air Force life cycle cost management program is designed to bring about reductions in system and equipment costs primarily through increased consideration and analysis of the ownership (operation, maintenance and support) cost implications of design alternatives. However, life cycle costs can also be reduced through reductions in development and production costs. The cost elements summed to obtain the program life cycle cost are listed in Appendix A.

Studies of current field experience data show that high ownership costs are not limited to new or complex subsystems. On one or more aircraft now in operation, items such as fuel tanks and starters are high maintenance cost items. Virtually everyone, who through management or engineering activities influences the design of any part of Air Force systems and equipment, makes decisions affecting life cycle costs.

Historically, working level concern about costs has essentially been left to cost and budget analysts. This has been unfortunate because they primarily estimate and report costs, not make decisions which determine the level of system and equipment costs. It is both impractical and undesirable to have cost and budget specialists take a larger role in making many decisions which influence life cycle costs. Many of these areas have a high component of engineering and involve detail design considerations. Therefore, Government and contractor engineers and specialists must consider life cycle costs in arriving at design and related program decisions. Program managers must take positive action to ensure they do.

A program manager's primary responsibility is to direct the resources available to him to achieve stated program objectives. In the past, programs have generally had clearly stated performance, schedule and acquisition cost objectives. In addition, some programs addressed, on a lower priority basis, ownership cost related objectives, such as maintenance manhours per flying hour and mean time between failure. In response to the current importance being placed on reducing life cycle costs, program managers must now place ownership cost objectives more on an equal basis with performance, schedule and acquisition cost objectives. To do this, managers must ensure that ownership cost objectives are established and must continually manage

program activities to achieve lower ownership cost, as well as performance, schedule and acquisition cost objectives. The 1978 revision of AFR 800-11, "Life Cycle Cost Management Program" specifically requires the establishment of both acquisition and ownership objectives for all programs.

Purpose

The purpose of this guide is to assist program managers in their efforts to ensure that life cycle costs are adequately considered in arriving at design and other program decisions. The guide is designed to alert the reader to the wide spectrum of design and development issues which can be addressed to reduce life cycle costs. It can also be used as a reference to help program managers assure that these issues are considered throughout the development and acquisition of their systems. The guide provides a list of questions or issues about design and program factors, which managers should address in arriving at the numerous design and program decisions which significantly affect life cycle costs. In addition, it briefly describes the type of analysis and information that program managers should require from their subordinates and contractors in response to these questions.

Scope

This section includes a description of the total scope of life cycle cost management activities and identifies that portion of these activities addressed in this guide. The three primary areas of life cycle cost management activities are shown in Figure 1. As the figure indicates, these activities have both unique and overlapping aspects. These activities are:

1. Preparation of life cycle cost estimates (total development, production and ownership costs), i.e., life cycle cost estimating.

2. Use of life cycle cost procurement procedures including contract incentive provisions to motivate the contractor to design and produce equipment with low life cycle costs, i.e., life cycle cost procurement.

3. Evolution of a final equipment and support system design which will result in low life cycle costs. Rigorous management and sound engineering can significantly influence the evolution of a low life cycle cost design through the numerous planning, design and program decisions associated with all system and equipment acquisitions.

The most important aspect these three activities have in common is the use of life cycle cost models. Appendix B includes a discussion of these models and their use. The unique characteristics of these three activities and the program manager's role in these activities are discussed in the next three paragraphs.

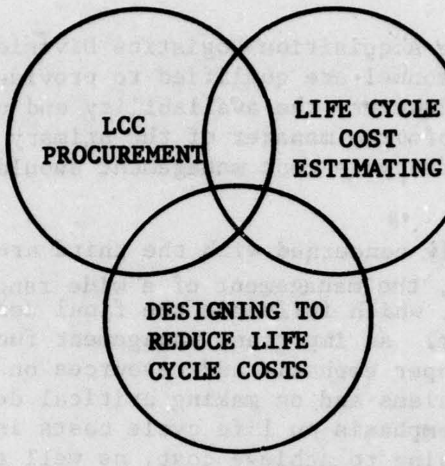

FIGURE 1

Life cycle cost estimating tasks can be delegated to the cost analysts supporting the program. However, ground rules must be established, clearly understood and periodically reviewed by the program manager to define exactly what such estimates include and exclude, and what assumptions were made. In addition, caution must be taken to assure that cost analysts are continually made aware of all design and program changes and that cost estimates are updated to reflect these changes. Program managers should review life cycle cost estimates prepared for them to ensure that they are complete and logical. Where life cycle cost estimates are made to compare his program with others or to be used for source selection decisions, a program manager must ensure there are logical and clear explanations for all significant differences between the estimates. To do this the managers should insist on getting all cost estimates broken out into as much detail as possible.

Life cycle cost procurement is a tool by which the government can influence the final design of an equipment or system through procurement techniques or incentives, without actually being involved in many individual design decisions. Since this approach implies a certain amount of government disengagement from the design process, incentive provisions must be very carefully prepared to ensure the incentive provisions do not induce any undesirable design features. In addition, changes must be held to a minimum as the program progresses. Life cycle cost incentive contract provisions generally involve the use of a life cycle cost model to forecast and subsequently assess ownership costs based on field experience. Preparation of these incentive terms and associated life cycle cost models is a specialized activity and program managers should seek assistance from appropriate procurement

specialists. ASD/Air Force Acquisition Logistics Division (AFALD) LCC/DTC Advisory Group personnel are qualified to provide valuable assistance in this area. However, the availability and use of such help does not relieve the program manager of the primary responsibility for deciding if and how life cycle cost management should be applied to his program.

This guide is primarily concerned with the third area of life cycle cost management activities, the management of a wide range of planning, design and development activities, which influence the final design and thereby the program life cycle cost. An important management function is continually placing the proper emphasis and resources on solving the most important current problems and on making critical decisions. Placing timely and proper emphasis on life cycle costs in arriving at design decisions and designing to achieve cost, as well as performance and schedule objectives, is the primary thrust of this guide. Management and engineering activities conducted to reduce life cycle costs may significantly affect both life cycle cost estimates and life cycle cost procurement provisions. However, this guide does not deal further with these two specialized areas of activity. Both of these areas of activity are discussed in the Life Cycle Cost Analysis Guide, which cites many other sources of information. Life cycle cost procurement is addressed in detail in the Life Cycle Cost Procurement Guide. Copies of both guides can be provided by ASD/ACC.

II. DESIGN INFLUENCES ON LIFE CYCLE COSTS

The design of an equipment or a system has a tremendous impact on velopment, production and ownership costs. It is generally recognized hat improving equipment reliability can reduce Air Force ownership osts. However, it is seldom easy to understand how ownership costs ary as a function of design or as a function of development and production costs.

A simpler design will generally result in both lower ownership costs and acquisition costs. However, in designing other equipment, where reliability improvements are required to achieve a reduction in ownership cost, development and production costs may be increased. The potential conflict between objectives becomes even more complex when it involves the full spectrum of design objectives other than development, production and ownership costs. Some of the often conflicting design objectives which must be addressed in evolving a single preferred design include: many aspects of performance, supportability, producibility, vulnerability, survivability, growth potential, safety, reliability, flexibility, maintainability, versatility and self sufficiency. With all of these and other factors to consider, arriving at a balanced preferred design can be difficult. Schedule constraints and unanticipated difficulties further complicate the design process.

A primary use of life cycle cost analysis is to assess different alternatives in terms of differences in ownership costs. Most life cycle cost models are too complex to be explained in this short guide. However, one can begin to understand how ownership cost can vary as a function of design alternatives by examination of a few of the standard cost factors which relate various support resource requirements to costs. CONUS standard cost factors include:

(EXPRESSED IN FY 76 DOLLARS)

1. Base maintenance labor and material cost per hour - $16.22
2. Depot labor and material cost per hour - $23.24
3. Surface shipping and packaging material and labor - $.59/lb
4. Average annual item management cost per stock-listed item - $104.20
5. Technical data cost per page - $220.00

Assuming a 600 aircraft force flying 30 hours a month for 15 years, a difference of one base maintenance manhour per flying hour results in over a 52 million dollar difference in base labor costs alone. A difference of one depot maintenance labor hour per flying hour and the

associated material would result in a 75 million dollar difference. For the same force the difference between a fifty hour and one hundred hour mean-time-between-removal subsystem, can mean a difference of 32 thousand removal and repair actions with the associated labor, parts, transportation, training, etc. costs. Use of existing subsystems and components can greatly reduce new item data and inventory management costs.

Fuel is a high ownership cost component for most aircraft systems. Engine efficiency can be improved by increasing engine temperatures. Unfortunately, higher engine temperatures almost always increase maintenance requirements. Therefore, in this and many other design areas, design approaches aimed at reducing one element of life cycle cost increase other cost elements. In the engine example, lower fuel costs would result in higher maintenance costs. As the result of the multiple and often conflicting ways design changes affect life cycle costs, careful and sometimes extensive trade studies must be conducted to arrive at the lowest life cycle cost design.

There are many design and program actions which can have a significant impact on life cycle costs. The list of actions included here has been divided into four common objectives. Some actions such as simplification can beneficially impact costs in several ways, such as lower production costs and improved reliability. Design actions already identified as offering opportunities to reduce life cycle costs include:

Lower Development and Production Costs

- Limited Performance Improvement Objectives
- Elimination of Non-Mission Essential Functions
- Design Simplicity
- Greater Use of Design Inheritance
- Greater Use of Standard and Commercial Products
- Use of High Production Volume Technology Parts
- Designing to Facilitate Multiple Source Competition
- Lower Data Requirements

Improved Reliability

- Limited Performance Improvement Objectives
- Greater Use of Proven Designs
- More Design Attention to Non Random Failures
- Design Consideration of Non Spec Use or Abuse
- Simplified Design
- Improved Quality Control
- More Efficient Development and Test Procedures
- More Representative Environmental Tests
- Timely Elimination of Software Errors
- Low Stress Peacetime Mode of Operations Option

Improved Maintainability

- Limited Performance Improvement Objectives
- More Design Attention to Maintainability
- Improved Test Equipment and Procedures
- Improved Accessibility
- Improved Reliability of Test Equipment
- Greater Support Equipment Standardization
- Use of Standard Components in Support Equipment
- Build In Self-Test Capabilities

Efficient Support Operations

- Reduced Proliferation of Subsystems
- Reduced Proliferation of Parts
- Reduced Maintenance Skill and Manpower Requirements
- Use of Common Support Equipment
- Reduction of Special Training or Maintenance Skill Requirements
- Reduced Logistics Pipeline Time Requirements
- Reduced Scheduled Maintenance Requirements

III. USE OF LIFE CYCLE COST ANALYSIS FOR DECISION GUIDANCE

General

Life cycle cost management is the consideration and analysis of life cycle costs or segments thereof, in various decisions associated with acquiring an item or defense system. It is required by numerous Air Force regulations. Life cycle cost analysis should proceed concurrently with and complement other design analysis activities. The application of life cycle cost management efforts should help ensure that there is a more logical balance among competing objectives associated with military equipment design activities. Historically adequate attention has not been given to the selection of design characteristics which limit or reduce ownership costs. Of particular concern are design characteristics which influence reliability, maintainability and requirements for training, spares and other support resources.

Life cycle cost management is applicable to all design decisions throughout the concept formulation, design, development, production and operational phases of aerospace systems and equipment, i.e., whenever decisions are made which affect design, and thereby influence life cycle costs. Air Force Regulation 800-11 states that Air Force policy is "to consider the full impact of life cycle costs in decisions associated with selection, design, development, procurement, production, modification, repair, or the use of defense materiel." Air Force Regulation 800-3 on Engineering for Defense Systems also calls for balancing several factors including performance and life cycle cost.

Design to Cost

The design-to-cost (DTC) concept is a key factor in a program's life cycle cost management efforts. DTC is a management concept that is used to control a product's life cycle cost. The concept is implemented by establishing rigorous cost goals for the new product early in the acquisition cycle. Cost, thus becomes a key design parameter. The goals usually relate to significant elements of the product's life cycle cost, i.e., development, production and ownership. These DTC goals are management and design objectives which establish a baseline for making tradeoffs between operational capability, performance, cost and schedule. AFR 800-11 requires cost related design goals be established and approved for acquisition and modification programs that involve design effort. As a minimum, cost goals are required to be established for: (a) average unit production cost, (b) unit operating crew and maintenance requirements, (c) operational reliability and maintainability parameters, and (d) other selected design controllable factors which significantly affect the life cycle cost of the product.

Life Cycle Cost Management Objectives

Effective application of life cycle cost management accomplishes the following: (a) Provides basis for review and logical establishment of economically feasible performance requirements. (b) Provides design guidance to reduce ownership costs of achieving specific performance objectives. (c) Promotes innovations of lower ownership cost designs. (d) Provides a common basis for comparing a wide spectrum of design objectives. To effectively achieve these objectives, designers must consider life cycle

costs as well as all design data and program constraints known at the time design decisions are made. Life cycle cost analysis results should not dictate design characteristics. However, they must be given proper consideration. The relative weight to be given to various factors and objectives affecting design decisions will vary from program to program.

Program managers generally operate in an environment of multiple and often conflicting objectives and limited resources. To adequately fulfill life cycle cost objectives with limited resources, program managers will have to make timely decisions on how many and which design decisions must be based on life cycle cost analysis. In circumstances where past experience clearly provides pertinent and logical life cycle cost reduction design guidance, life cycle costing objectives may be achieved with little or no formal life cycle cost analysis.

Managing to Achieve Life Cycle Cost Objectives

Life cycle cost management efforts potentially add two new areas of activity to those previously assigned to a program office,i.e., life cycle cost estimating and life cycle cost procurement. The program manager must ensure that the required applicable actions are taken in these two areas. With respect to the primary area of life cycle costing activities addressed in this guide, i.e., designing the equipment to reduce costs, the manager's role is primarily to ensure that usual development and production functions are done with significantly increased emphasis on the consideration of life cycle cost implications of design and other decisions. This often includes the estimation and assessment of the life cycle cost differences among design and program alternatives.

Historically, performance objectives have been the first and most important criterion against which military equipment and in turn program personnel were assessed. Therefore, emphasis on meeting performance objectives often diverted design attention to this area, and away from factors which could reduce ownership costs. As a result, proper design attention was seldom given to reducing life cycle costs until after many design decisions, needed to meet performance objectives, had been made. Unfortunately, many of these performance oriented design decisions significantly increased life cycle costs. Therefore, if a program manager is going to assure that life cycle costs, especially ownership costs, are adequately considered in design, he must taken action from the outset of design activities to ensure that the designers are directed and motivated to look well beyond performance objectives in evolving the design.

One problem that may arise and cause difficulties is that a manager may find himself saddled with an impossible set of performance, cost and schedule objectives. This may occur as the result of new information provided by detail design studies or by development test results which indicate unanticipated problems. It may also occur as the result of planning studies which had to be based on preliminary or inadequate data,

or unwarranted optimism. Whatever the cause, it is critical that a manager use the latest data available to continually keep the program proceeding toward a well balanced set of cost, schedule and performance objectives. This may require significant modification of earlier objectives based on later information. This is critical from a life cycle cost standpoint. Historically, when programs have continued to pursue impossible or near impossible design, performance or schedule objectives, they have generally resulted in systems and equipment being deployed with low reliability, high support costs and less than predicted performance. This in turn has resulted in high ownership costs and significant degradations in planned cost effectiveness.

During the design of systems and equipments, considerable testing is usually done to provide design decision guidance. Most of this testing is both time consuming and expensive. The result in the past has often been that test activities were curtailed when continued testing would have been a more appropriate course of action. Life cycle costs are closely related to the reliability equipment demonstrated in the field. Therefore, both realistic and adequate reliability tests are essential to develop and demonstrate equipment with satisfactory and known reliability characteristics prior to production commitment decisions. To achieve life cycle costing objectives, managers will have to make many difficult decisions concerning the conditions and duration of test programs, and what actions to take based on test results.

In addition, appropriate design studies and tests should be conducted to assure that the causes of premature wear, fatigue and corrosion induced failures are elminated from the design. A large fraction of current ownership costs are associated with non-failure maintenance actions such as inspection, adjustment and cleaning. Design studies to minimize these maintenance actions are also required.

An important point to remember is that the development of new equipment, which will be reliable and easy to maintain, usually involves significant design and development work solely to achieve the required reliability and maintainability objectives. Work up to the point of demonstrating adequate performance with some sort of prototype device, may be less than half the total effort required to develop and demonstrate a lower life cycle cost design. However, the overall design task will be accomplished most efficiently by considering life cycle cost related objectives from the outset of design, rather than waiting until after performance objectives have been demonstrated.

It is important that every manager clearly understand that program life cycle costing activities cannot be delegated to one or a small number of experts. Specialists may be required for some tasks, such as developing a life cycle cost model. However, if life cycle costing is to be successfully applied to the overall program throughout the acquisition process, all program and contractor personnel who make decisions affecting life cycle cost, must consider life cycle cost in arriving at decisions in their areas of reponsibility. This includes personnel involved in planning, engineering, procurement, resource and decision analysis and management.

Life Cycle Cost Analysis

Feasible and efficient life cycle cost analysis methods will vary widely depending on the phase of the program, the nature of the equipment, the availability of data, the nature of decisions under study, and many other factors. Many life cycle cost design trade studies will require at least the adaptation of existing methods. Life cycle cost design trade studies for new products will often require development of new analysis methods or the adaptation of existing models reflecting the unique characteristics of the equipment.

The primary objective of life cycle cost design trade studies is to provide visibility with respect to the life cycle cost implications of various design and performance alternatives. Life cycle cost analysis of design alternatives requires knowledge of both design and cost analysis. Since engineers or design specialists have the primary role in evolving the final design, they can most effectively take the lead in performing beneficial life cycle cost design trade studies.

Life cycle cost analysis methods will vary from application to application. They are generally characterized by use of life cycle cost models to estimate and compare the life cycle cost of alternatives. Appendix B includes a discussion of such models and important aspects of effectively using them.

IV. LIFE CYCLE COST RELATED DESIGN ISSUES

This section contains a list of issues program managers should review as early as possible in the program, and address if applicable to their program. The list was prepared initially for aircraft and aircraft subsystems. However, most of the questions are general and are appropriate for other types of equipment.

The issues listed have been put into the form of questions. A program manager should be prepared to answer these questions as part of his overall responsibilities to reduce life cycle costs. He will have to delegate most of the analysis work needed to substantiate his position on these issues to subordinates and contractors.

A program manager should take the general questions provided and using his knowledge of his specific program, formulate a more specific set of life cycle cost related questions tailored to his program. He can then have his subordinates and contractors address these questions with appropriate life cycle cost design trade studies. In preparing specific questions many factors must be considered including the characteristics of the specific equipment being developed, knowledge of ownership cost drivers of similar equipment currently in operation, program objectives, the relative roles of the government and the contractor in evolving the final design, and potential opportunities to reduce ownership costs.

This list of issues is not considered to be complete. It is offered only as a list of program and design related issues known to have significantly affected the life cycle costs of past programs. To the extent that some issues may not be relevant to a specific new program, program managers should assure that life cycle cost analysis resources are not wasted on analysis of them. However, where logic suggests that other issues will significantly affect the life cycle costs of his equipment, a program manager should include them in his list of specific issues to assure that design and other program decisions are based on proper consideration of life cycle costs.

The list of questions has been divided into system, subsystem and program considerations. In addition, appropriate subheadings have been provided to help make the full spectrum of questions more understandable and to assist a program manager in delegating life cycle cost analysis tasks.

LIST OF LIFE CYCLE COST DESIGN TRADE STUDY ISSUES

A. System Considerations

1. System Performance

a. How has it been shown that the selected system concept is the lowest cost way of achieving the essential program objectives?

b. How does life cycle cost (LCC) vary with the level of system performance?

c. Can special provisions be made to achieve high levels of performance which may not be required from all units or all of the time and thereby reduce the cost of other units?

2. Operational Concepts

a. How do life cycle costs vary as a function of operational concepts?

b. How do life cycle costs vary as a function of utilization rates?

c. Can life cycle costs be reduced through increased use of simulation or engine power management in training?

3. Survivability/Vulnerability

a. How does system life cycle costs and military worth vary as a function of survivability/vulnerability?

b. Have survivability/vulnerability design decisions been based on life cycle cost consideration?

4. System Maintenance Concepts

a. How does life cycle cost vary with system maintenance concept?

b. How does the level of operational unit self-sufficiency affect life cycle cost?

c. How have preferred maintenance concepts been selected based on minimum life cycle costs?

d. How has it been shown that the system can be maintained efficiently for both high and low levels of operations?

e. What are the relative life cycle costs of contractor versus Government organic support during the initial program operational period?

f. Can pre-flight, turn around and post-flight inspections be accomplished with little or no support equipment?

5. System Reliability

a. How does LCC vary as a function of the level of system reliability?

b. How does LCC vary as a function of mission success?

c. How does system reliability vary as a function of reliability of all the various subsystems?

d. How will subsystem reliability targets be set to achieve the required system availability at the lowest life cycle cost?

e. Have procedures been established to assure that the LCC implications of reliability problems are continually assessed and timely corrective action taken in critical areas?

f. Can contingency provisions be made for back-up equipment or procedures to provide high reliability which may be required only part of the time?

B. Subsystem Considerations*

1. Subsystem Performance

a. Are subsystem performance requirements consistent with required system performance requirements?

b. What are the subsystem performance parameters which significantly affect life cycle costs?

c. How does the level of subsystem performance affect life cycle costs?

2. Subsystem Design Concept

a. Subsystem Design Concept

(1) Does the selection of a design concept significantly affect life cycle costs?

* Aircraft subsystems include: structures, flight control, avionics, propulsion, hydraulics, electrical, fuel, environmental control, life support, armament, landing gear, instruments, crew escape and support equipment.

(2) Was the lowest cost subsystem design concept or approach determined?

(3) Has the use of subsystem interface standards been considered to encourage multiple sources?

(4) Has partitioning been considered to reduce life cycle costs?

(5) Can life cycle costs be reduced through use of a digital design concept?

b. Critical Subsystem Design Parameters

(1) What subsystem design parameters significantly affect life cycle cost?

(2) Can the cost sensitivity to critical design parameters be reduced?

(3) Can adequate performance be attained while curtailing critical design parameter values?

c. Subsystem Design Simplicity

(1) Can the parts count be reduced?

(2) Can a major part count reduction be achieved with only a small performance penalty?

(3) Are all parts needed for required functions?

(4) Can one part be made to replace two or more other parts?

(5) Can complex adjustment procedures be eliminated or simplified to reduce cost?

(6) Are adjustment controls sequentially located?

d. Subsystem Design Use of Proven Components

(1) Can subsystems be designed around field tested and proven components?

(2) How has maximum use been made of design inheritance?

e. Subsystem Design Commonality

(1) Can costs be reduced by repeated use of common parts and assemblies?

(2) Can one device be used for multiple functions?

(3) Have unique right and left handed parts been avoided wherever possible?

f. Subsystem Design Standardization

(1) Can a device now in service adequately perform this subsystem function at a lower life cycle cost?

(2) Can the subsystem design requirement be met by modification of existing and field tested hardware at lower costs?

(3) What efforts were taken to assure standard parts were utilized to the maximum extent possible?

(4) Was the use of standard hardware modules evaluated?

g. Subsystem Design Materials Selection

(1) How does the selection of subsystem materials affect life cycle costs?

(2) Have materials selections been made to reduce costs?

(3) Will the materials be readily available throughout the life of the system?

h. Other Subsystem Design Considerations

(1) Has producibility been considered throughout the design process?

(2) Will needed parts be in production throughout the life of the program?

(3) Are vibration sensitive subsystems isolated from gun installations or other major vibration sources?

3. Subsystem Reliability

a. For the required level of performance, what is the relationship of subsystem reliability to life cycle costs?

b. Has a trade-off been made between reliability and maintainability?

c. Has a reliability target been set based on life cycle cost considerations?

d. Have realistic environmental factors been adequately considered in establishing reliability, program and test requirements?

e. Have storage requirements been considered in reliability specifications?

f. Has adequate reliability demonstration testing been planned prior to production commitments?

g. Is there a formal methodology to improve reliability prior to reliability demonstration tests?

h. How does use of redundancy affect life cycle costs?

i. Has derating been evaluated as a means of improving reliability?

j. Have appropriate burn-in test procedures been planned for all production items?

4. <u>Subsystem Maintainability Considerations</u>

a. <u>Subsystem Maintenance Philosophy</u>

(1) Have costs been considered in arriving at repair or throw away decision for all components?

(2) Have optimum repair level decisions been made for all reparable parts?

(3) Can costs be reduced by making provisions for in-position maintenance?

(4) Have optimum repair level factors been considered during design?

(5) Have the LCC implications of overhaul versus on-condition maintenance been considered during subsystem design?

(6) What are the relative life cycle costs of organic versus contractor depot repair?

(7) Can subsystem condition monitoring be used to reduce life cycle costs?

b. Subsystem Component Placement

(1) Are components functionally grouped to facilitate fault isolation?

(2) Have provisions been made to prevent damage to vulnerable areas?

(3) Can LRUs be removed without use of support equipment?

(4) Have APU and jet fuel starter exhaust been directed away from maintenance activity locations?

(5) Is there safe access to power distribution panels and circuit breakers during ground engine operations?

(6) Can the packaging density be reduced?

c. Subsystem Maintenance Accessibility

(1) Are all components requiring frequent adjustment, servicing, calibration or replacement easily accessible?

(2) Have adequate provisions been made where visual inspection will be required?

(3) Are adequate test points and failure indicators easily accessible to check out all replaceable items?

(4) Are access openings adequate for the work to be performed and tools to be used?

(5) Will the removal of external stores be required to accomplish maintenance?

d. Support Equipment (SE)

(1) Can existing support equipment be used?

(2) Can costs be reduced by use of BITE versus SE?

(3) Have the requirements for peculiar SE/tools been minimized?

(4) Has the use of standard hardware modules in SE designs been adequately evaluated?

(5) Has the LCC of alternate SE concepts been assessed?

(6) Is standard programming language being used in support equipment utilizing computer programs?

(7) Have the optimum R&M characteristics of complex items of support equipment been determined and established as design objectives?

(8) Are standard cushion packs being used wherever possible to avoid the need for unique container designs?

e. Subsystem Maintenance Procedures

(1) Have procedures been established for timely fault identification and isolation?

(2) Has the need for non-standard tools been reduced or eliminated?

(3) Have maintenance procedures been made as simple as possible?

(4) Will components be properly labeled to facilitate maintenance?

(5) Has appropriate use of job performance aids been considered during design?

C. Program Execution Issues

1. Contractor Selection

a. Are detailed descriptions of desired life cycle cost objectives and required cost trade-off studies being provided to the contractor?

b. Have adequate time, plans and resources been provided to evaluate design and associated life cycle cost differences during source selection?

c. Have the prospective contractors been provided a common life cycle cost model(s) to use for evaluation of tradeoff studies, source selections and Engineering Change Proposals?

2. Development Contracts

a. Is the development schedule realistic with respect to achieving satisfactory system and subsystem reliability?

b. Has the contractor been required to conduct and report LCC design trade studies on critical and specified design issues?

c. Has a process been established to quickly review and resolve any LCC-performance objective conflicts which may arise?

3. Qualification/Verification Testing

a. Have testing conditions which adequately represent field conditions been specified?

b. Have provisions been made to make timely and effective use of all test results to assure full assessment of their LCC implications?

c. Has adequate time, including an adequate allowance for a test-fix phase and unforeseen problems, been provided to fully demonstrate satisfactory system and subsystem reliability prior to production decisions?

d. What plans and provisions have been made to achieve reliability growth in the field?

e. Have adquate provisions been made to validate and verify the system software?

4. Maintaining Competition

a. Has use of proprietary design equipment and components been avoided wherever possible?

b. Has the use of sole source parts and materials been held to an absolute minimum?

c. Is competition being maintained as long as possible or until the product is well defined?

5. Other

a. Does the contractor base make/buy decisions on cost reduction considerations?

b. Are life cycle costing and design to cost concepts properly implemented in subcontracting activities?

c. Are contractors required to perform design trade studies based on LCC analysis?

d. Have specifications and standards been scrubbed to be consistent with the minimum stated program needs?

e. Has a program been developed to educate and motivate contractors in life cycle cost and design to cost concepts?

f. Have cost goals been established?

g. Have contractors been requested to identify the top LCC drivers and to identify and challenge all cost driving program requirements, policies, etc.

h. Does the furnished LCC model accurately reflect the program, and is it simple enough so as to encourage its frequent use?

V. ADDITIONAL GUIDANCE

Responsibility for all the issues raised in the last section is not being assigned to program managers for the first time. Many of them relate to reliability, maintainability, cost effectiveness analysis and other activities which are not new. What is new is the amount of emphasis now being placed on reducing life cycle costs, and ownership costs in particular. Increased consideration of life cycle costs during design will require extra work by both government and contractor personnel. However, the magnitude of cost problems facing the Air Force requires that program mangers take all possible avenues to control costs. Design activities are an area where much can and must be done to meet life cycle cost management objectives.

Resources available to program managers are both limited and costly. Therefore, considerable management attention will be required to assure that efforts designed to reduce life cycle costs are directed at critical issues and efficiently produce useful results. Where one program has derived a sound basis for design decisions leading to lower life cycle costs, it is important that this guidance be shared with other programs. Therefore, a program manager may find it beneficial to review life cycle cost design trade studies on related programs. All program managers should ensure that life cycle cost reduction design guidance developed for their programs is made readily available to other programs.

There will be a period of transition before rigorous consideration of life cycle cost becomes a way of life in all aspects of the design of Air Force equipment. Managers will need help to carry out their responsibilities. Help is available in structuring life cycle cost models and analysis from several sources. The Air Force Acquisition Logistics Division (AFALD) can provide assistance through its staff and collocated offices at all AFSC Product Divisions. Help may also be available from personnel experienced in life cycle cost analysis in the cost analysis organizations at each AFSC Product Division. Most contractors are aware of the Air Force requirement for life cycle cost analysis and have or are developing this capability. However, all contractor developed life cycle cost analysis methods and assumptions should be clearly understood and validated before using the analysis results as the basis for program office decisions. This is often most effectively accomplished by providing the contractors with analysis models, program assumptions and a specific set of issues to be addressed.

Program managers have primary responsibility for the overall design of new systems and equipment. They must supervise and coordinate the work of many government personnel who guide contractors, who in turn make most detail design decisions. The program manager and his staff, through their leadership, guidance and preparation of procurement material, will strongly influence how well contractors understand and work to meet life cycle cost management objectives. The better program office personnel understand how design alternatives affect life cycle costs, the more efficiently they can work with contractors to assure future Air Force equipments and systems are designed to meet life cycle cost reduction objectives.

APPENDIX A

COST ELEMENT STRUCTURE

This appendix, based on material in AFR 800-11, provides a generalized aircraft cost element structure used in life cycle cost management efforts.

100 Research and Development

- 101 Development Engineering
- 102 Producibility Engineering and Planning
- 103 Tooling
- 104 Manufacturing - Prototypes (Including Spares)
- 105 Other
- 106 General and Administrative (G&A)
- 107 Profit

200 Investment

- 201 System Investment
  - 201.1 Investment Nonrecurring
    - 201.1.1 Initial Production Facilities - Engineering
    - 201.1.2 Initial Production Facilities - Tooling
    - 201.1.3 Other
    - 201.1.4 General and Administrative (G&A)
    - 201.1.5 Profit
  - 201.2 Investment Recurring
    - 201.2.1 Production (LRIP and Full Production)
      - 201.2.1.1 Engineering
      - 201.2.1.2 Tooling
      - 201.2.1.3 Manufacturing
        - 201.2.1.3.1 Prime Manufacturing
        - 201.2.1.3.2 Subcontract (Components & Assemblies)
        - 201.2.1.3.3 Purchased Equip/Parts
        - 201.2.1.3.4 Quality Control
        - 201.2.1.3.5 Other
        - 201.2.1.3.6 General & Administrative (G&A)
        - 201.2.1.3.7 Profit
        - 201.2.1.3.8 Engineering Changes
        - 201.2.1.3.9 First Destination Transportation

APPENDIX A (Cont'd)

202 Support Investment

202.1 Support Equipment
202.2 Training Equipment and Services
202.3 Documentation
202.4 Initial Spares and Repair Parts
202.5 Spare Engines
202.6 Facilities (Non Production)
202.7 War Reserve Materiel

300 Operating and Support

301 Deployed Unit Operations

301.1 Aircrews
301.2 Command Staff
301.3 POL
301.4 Security
301.5 Other Deployed Manpower
301.6 Personnel Support

302 Below Depot Maintenance

302.1 Aircraft Maintenance Manpower
302.2 Ordnance Maintenance Manpower
302.3 Maintenance Materiel
302.4 Personnel Support

303 Installation Support

303.1 Base Operating Support
303.2 Real Property Maintenance
303.3 Personnel Support

304 Depot Maintenance

304.1 Manpower
304.2 Materiel

305 Depot Supply

305.1 Materiel Distribution
305.2 Materiel Management
305.3 Technical Support

306 Second Destination Transportation

APPENDIX A (Cont'd)

307 Personnel Support and Training

- 307.1 Individual Training
- 307.2 Health Care
- 307.3 Personnel Activities
- 307.4 Personnel Support

308 Sustaining Investments

- 308.1 Replenishment Spares
- 308.2 Modifications
- 308.3 Replenishment Ground Support Equipment
- 308.4 Training Ordnance
  - 308.4.1 Munitions
  - 308.4.2 Missiles

APPENDIX B

SUPPLEMENTARY DISCUSSION OF LCC ANALYSIS METHODS

Search for and Identification of Alternatives

A key aspect of meaningful life cycle cost design trade studies is identification of design alternatives which have a range of associated life cycle costs. This effort includes the search for significantly lower life cycle cost design alternatives, some of which may not meet all initially stated performance objectives. Once alternatives are identified, they must be adequately described so all significant differences in life cycle costs and other factors can be estimated and evaluated.

Life Cycle Cost Models

Life cycle cost models have two primary functions. One is to specify how and which elements of cost are to be aggregated to a total life cycle cost value. The other primary function is to relate system and equipment, design, performance, program, deployment or other parameters, to the value of one or more life cycle cost elements. This is done using specific mathematical equations. The selection of the cost elements to be included is normally a function of the decision to be made and is based on whether the costs are considered both relevant and significant.

There are five primary requirements which should be met if a life cycle cost model and the analysis based thereon is to be of value.

> Completeness: The life cycle cost model must include all elements of life cycle cost appropriate to the decision issue under consideration. If a total life cycle cost estimate is needed for planning or budgetary purposes, the model must include essentially all elements of program cost. However, where the decision under consideration affects some but not all cost elements, only those costs affected need be considered in a life cycle cost model used to compare the relative costs associated with that decision issue. Where appropriate, the cost differences between alternatives should be considered for at least the following life cycle cost elements: RDT&E, procurement of the end item, initial and replenishment spares, spare engines and modules, off-equipment repair, on-equipment repair, new item inventory management, support equipment, training equipment, data, new facilities, training activity, operating personnel, fuel, and disposal.

Sensitivity: To be useful for design trade studies and other decisions, life cycle cost models must be sensitive to the specific design or program parameters under study, in order to resolve life cycle cost differences among the alternatives. While this should be obvious, it is a significant problem because most life cycle cost models are not sensitive to the many design and performance parameters associated with Air Force systems and equipments. This problem is aggrevated by the fact that many different types of Air Force equipment have unique sets of design and performance characteristics, necessitating the need for different life cycle cost models to evaluate design trade studies.

Validity: The validity of a life cycle cost model is a measure of how well the model represents the real-world environment in question. This is paramount if a life cycle cost model is to be used to compute the life cycle cost differences between design alternatives, and these differences are used as a basis for decisions. Given the model, the analyst must verify the input data to ensure that the computed model output costs are both logical and consistent. Furthermore, in using life cycle cost model results, some judgment may be required with respect to how valid estimated cost differences are, and just how much weight one should give to estimated life cycle cost differences relative to other factors. To assure valid results one has to examine the computed potential savings and the non-design related factors involved in fully realizing design related potential savings. Many manning and operating practices are such that 100% of potential life cycle cost savings cannot reasonably be expected. This must be taken into consideration in assessing the validity of life cycle cost analysis results.

Availability of Input Data: Accurate input data must be availability for a life cycle cost model to be useful. Some life cycle cost models are of questionable value because good estimates of important input factors cannot be obtained, or if obtained from vendors, cannot be validated by Government personnel as true and an equitable basis for comparisons among vendors. If work is undertaken to develop a new model for a specific application, it is important that it be done with full recognition of any limitations there may be on the availability of valid input data.

Documentation: The fact that considerable latitude is allowed in conducting life cycle cost design trade studies dictates that the results be well documented so the work can be quickly reviewed and easily understood by others. All analysis methods and assumptions must be clearly documented. Of particular importance is how new or proposed equipment reliability and maintainability parameter values were obtained. A logical relationship or basis for extrapolation should always be shown between proposed equipment reliability and maintainability parameter values and historical field experience data on related equipment.

Analysis Results: The end product of a design trade study should be analysis results which can serve as a valid and logical basis for selecting a preferred design. Included in this basis for decision must be the life cycle cost differences for a spectrum of appropriate design alternatives. Life cycle cost design trade study analysis results can generally best be displayed in two forms. First, the life cycle cost and other descriptors of a spectrum of design alternatives should be displayed in tabular form. In addition, it is often useful to have sensitivity plots to show how the life cycle costs change as a function of selected parameters appropriate to the equipment under study.

Consideration of Other Design Objectives: Many design objectives are important in addition to minimum life cycle cost. This guide does not direct that life cycle cost supersede other objectives. However, it does suggest that, when design characteristics related to the design issues listed in Section IV are selected to achieve other objectives, and which increase life cycle costs, the magnitude of the life cycle cost increases should be determined. The program manager should then be prepared to justify these extra costs in terms of their magnitude and the benefits derived from such decisions.

APPENDIX C

REFERENCES

Summary Report: Engineering Evaluation Panel, F-16 Cost Effectiveness Working Group, July 1975.

Final Report: Support Evaluation Panel, Volume II, F-16 Cost Effectiveness Working Group, July 1975.

Design Guidelines for Reduced Life Cycle Cost of Advanced Systems, AFFDL-TR-75-75, Volume I, June 1975.

Design Guidelines Handbook, AFFDL-TR-75-75, Volume II, June 1975.

Comparison of Military and Commercial Design-To-Cost Aircraft Procurement and Operational Support Practices, AFFDL-TR-75-64, July 1975.

Supplemental Life Cycle Costing Program Management Guidance, ASD/ACL, January 1977.

Report of Acquisition Logistics Lessons Learned During Conceptual and Validation Phases of The Advanced Medium Short Take-Off and Landing Transport Program (AMST), AMST DPML, 1978.

AFR 800-11, Life Cycle Cost Management Program, 22 February 1978.

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